The Role of the Deep Space Network for Cassini

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Abstract:

NASA's Deep Space Network (DSN), managed by the Jet Propulsion Laboratory, is a set of three deep-space communications centers, located near Canberra, Australia; Madrid, Spain; and Goldstone, California (USA). Each site has several large radio telescopes, which range from 26m in diameter to 70m. The primary frequencies in use by the DSN are S-band (2.1, 2.3 GHz) and X-band (7.1, 8.4 GHz). The tracking services offered include telemetry, Doppler and range measurements, and radio science. The DSN uses ultra low noise antenna front ends and precision frequency and timing references to ensure that the signal received is as strong and stable as possible.

Cassini Radio Science has several categories of requirements for DSN tracking services. The three main areas for upgrade are in Ka-band, long-term frequency stability, and short-term frequency stability/phase noise level.

For the Gravitational Wave Experiments (GWE), the DSN must provide a station having 2-way Ka-band (32, 34 GHz), simultaneous X and Ka-band uplinks with 1 X-band downlink and 2 Ka-band downlinks, and greatly enhanced long-term stability (1000+ sec). DSS 25, located in the Goldstone complex, will provide these capabilities. GWE tracking outside the X/Ka station will consist of a single X/X link. The Saturn system occultation experiments require S, X and Ka-band downlinks with greatly enhanced short term stability (1-100 sec) and phase (spectral) noise levels (1 Hz - 10 KHz from carrier). X and Ka-band tracking will be done at DSS 25 with the nearby 70m antenna providing the S-band reception. At the other sites, the 70m will provide S and X only.

Ka-Band: A primary new capability for Cassini will be the DSN's first two-way Ka-band communications link, available from DSS 25 at the Goldstone Deep Space Communications Complex. The uplink consists of a tunable Ka-band exciter (32 GHz), an 800 W klystron transmitter, and 78 dBi of gain from a 34m beam-waveguide antenna and optics. DSS 25 will also be able to simultaneously transmit a 3.8 kW X-band uplink. The downlink consists of the antenna and separate downlink feed, a Ka-band HEMT low noise amplifier (21 K noise temperature), frequency downconversion to 300 MHz, and tunable bandpass recording up to 16 MHz wide. In addition, the 300 MHz signal may also be phase-locked loop detected in real-time, with precision Doppler measurements. The Ka-band downlink capability will be available as an engineering demonstration in Nov. 97. The full implementation of the Ka-band system will be available in April 2001, in time for the first Cassini GWE test.

Long-Term Frequency Stability: There are several major contributors to the long-term frequency stability of the station. These include fluctuations in the troposphere (causing apparent path-length fluctuations), movement of the antenna dish, stability of the primary frequency reference, and the inherent stability of the various transmit and receive components such as the exciter and receivers. The DSN is working on calibrations or improvements in all these areas. DSS 25 will have a sophisticated set of media calibration equipment, including an Advanced Water-Vapor Radiometer developed and built at JPL. The Media Calibration subsystem will calibrate tropospheric noise to better than 1.5 E -15 (Allan standard deviation). Stability of the primary frequency reference will be improved by adding active feed-bank stabilization to the frequency distribution. The reference itself will be a hydrogen maser. The stability of the antenna dish is being calibrated by a set of newly-designed test gear which uses a combination

of techniques to determine overall stability while the antenna is in various modes of operation. Finally, the exciters and receivers have been designed specifically to provide high stability. The requirement for overall station long-term (1000+ sec) frequency stability is 3 E -15 at Ka-band, and 1 E -14 at X-band.

Short-Term Frequency Stability/Phase Noise Level: The main technology focus for short-term frequency stability and phase noise level is the development of an new reference oscillator. JPL's Compensated Sapphire Oscillator will provide a stability of parts in 10E 16 at time intervals 1 - 100s, and a phase noise level of -68 dBc/Hz at 10 Hz. The requirement for overall station short-term frequency stability (all bands) is 4e-14 at 1 sec, and the requirement for overall station phase noise level at Ka-band is -64 dBc/Hz at 10 Hz.